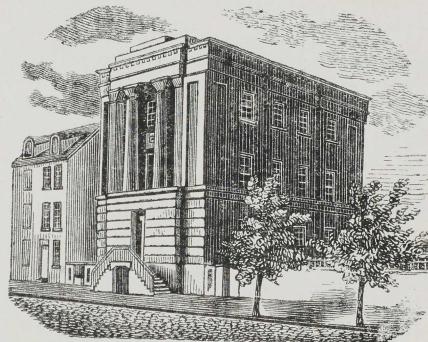


AN ESSAY ON  
Endosmosis.

RESPECTFULLY SUBMITTED TO THE FACULTY OF THE



HOMœOPATHIC MEDICAL COLLEGE  
OF PENNSYLVANIA,

On the                    day of January, Eighteen Hundred and  
Fifty-seven.

By Milton P. Hayward  
of Hartford, Connecticut

## "Endosmosis,

On bringing up this subject for consideration I do not purpose to enter into a minute detail of all the operations of nature, both in the animal and vegetable kingdoms which are partially or wholly attributable to this force, but on the contrary I shall only consider some of the more important facts, such facts as are familiar to all physiologists, and such facts as should be interesting to us as students of physiology. I shall also strive to make clear some of the fallacies of attributing to a vital or mysterious force those operations which are fully and clearly proved to depend on purely physical or chemical principles. And the time will undoubtedly come as science advances when many of the

phenomena taking place in the living tissues, which are now attributed to this mysterious or vital force, will be explained on the same principles. That there <sup>is</sup> a vital force influencing the living tissues I think no one for a moment can doubt, but some men too eager to find a cause for every thing have undoubtedly attributed altogether too much to this force, but let us see for a moment if we cannot artificially institute some of those operations which are blindly attributed to this force, and if we can without the aid or even presence of it, then our point is at once proved. If into a tube closed at one extremity by a membrane either of organic or inorganic structure, provided it has a greater affinity for water than for

alcohol, be placed some alcohol and the closed extremity be placed in some water a curious phenomenon takes place, there is an immediate action set up, the membrane having a greater affinity for the water or in simpler language the membrane being more easily wetted by the water than by the alcohol, therefore the water permeates the membrane and by the influence of capillary attraction there is a passage of water from the exterior to the interior of the tube, this phenomenon which is nothing more or less than capillary attraction was named by its discoverer Dutrochet Oncosmosis, and which term Dr. Mann of England says is a very appropriate one, but Dr. Draper says that it

is to be regretted that this term has been applied since the whole action can be accounted for by capillary attraction. The term is from the Greek, which means within and impulse which seems to express the action. Therefore I agree with the former gentleman although the latter may be right. At the same time there will be a counter current in the opposite direction, a portion of the alcohol passing out to mingle with the water but in a much less quantity and this action is kept up till the fluids become of equal density or so nearly so that they are incapable of sustaining the currents. This latter current or the passage of the alcohol out was named by Dutrochet Osmosis, from the Greek out of and impulse.

These two processes bear a very close resemblance to and are undoubtedly identical with a great number of operations constantly taking place in the living tissues. They explain on purely physical principles many operations which were formerly attributed to a vital or some other mysterious principle unknown. These latter facts make the subject one of great interest to the physiologist, and one well worthy of his research, for it sheds light in his pathway, explaining many of the operations of nature going on in the living body without which could not be known, or at least only guessed at by some charlatan, who more for the sake of emulation than for the advancement of science has

tried to explain by theories and worthless speculations. Of the many operations which are carried on in the living organism by this power several of the more important and interesting ones as above stated will for the present occupy our attention. And first comes absorption, and here we have two kinds first by the blood vessels and second by the lacteals. In the stomach the more fluid parts are taken up directly by the blood vessels of that organ, nothing separating the blood on the one hand and the fluid of the stomach on the other but membrane, and experiment has amply proved that it is through the influence of endosmosis that this absorption is carried on, and

we have very good reasons to believe that  
osmosis is at the same time carried  
on from the blood vessels (veins principally)  
to the cavity of the stomach. So also it  
is with absorption by the lacteals, which  
were formerly supposed to open into the  
intestines with their mouths open to  
receive the chyle, but it is now proved  
that this is never the case, but in every  
instance there is interposed between  
the chyle in the intestine and the lacteals  
a membrane which the chyle has to  
pass through, therefore there is but little  
doubt but that absorption is nothing  
more nor less than capillary attraction  
filtering the products of digestion  
through animal membranes. In  
many tissues of the system the supply

of nutriment is transmitted to them by this inhibition without any system of vessels whatever, thus it is in proper cellular cartilage, the dense tissue of bones, teeth &c. thus also it is with the epidermis and epithelial cells of mucous membrane, the latter derive their nutriment from the vessels on the opposite side of the basement membrane whereon they are situated. It is by this inhibition that the ovum first augments and all primary cells seem to be nourished by the same power. By the law of the diffusibility of gases which is also by the same power, we can explain how oxygen is taken into the blood corpuscles or cells and carbonic acid gas given off in the act of

respiration. In some cells the inward current of fluid, may sometimes have such an action on the fluid, contained within the cell as to form an internal membrane, thus converting a non nucleated into a nucleated cell. Again according to Draper the secretions and excretions, and especially the latter, are all a simple strainage through membranes, and are probably influenced by this inhibition, but there is an opportunity for more research on this subject, before the question can be settled. The circulation in the capillaries, the accumulation of fluid, in the serous cavities producing some of the different kinds of dropsy &c, may be and probably are

influenced by this power. We find it also obtaining in the vegetable world, using its influence in many operations there. The circulation in the vegetable cell is like that in the animal, and its source of nutriment derived in the same way. The spongioles at the extremities of the roots of the different vegetables absorb nutriment from the earth in the same way as the nutriment of the animal is absorbed, that is through a membrane. The rise of sap in the vegetable world is dependent on the same force, the sap rising through the capillaries in the substance of the plant or tree, the leaves performing the part of the lungs in the animal.

only instead of absorbing oxygen and giving off carbonic acid gas we find the reverse obtaining, the oxygen passing off from the leaves, under the influence of the light of the sun, by exosmose and the carbonic acid gas uniting with the sap under the same influence by endosmose, converting the sap into a more dense or glutinous liquid. and in artificial experiments we find that water will readily pass through a membrane driving out as a general rule the more dense or gummy solution, so also the sap rising up passes into the leaf and drives out the glutinous sap which has become carbonized and takes its place, this also becoming carbonized is in its turn driven out

by the ascending sap, and thus the circulation in vegetables is kept up, or at least, this nutritive change going on in the leaves is undoubtedly the primary cause of the circulation. It is also probable that the respiration of animals is the primary cause of their circulation, though the minor causes may be many. One of the most splendid examples of this power in the vegetable kingdom is found obtaining in the Momordica elaterium or squirting cucumber, as the fruit commences to ripen, by some peculiarity of the plant, endosmosis and exosmosis take place through a membrane contained within the fruit, one part becoming highly

distended by the action finally ruptures or bursts and not unfrequently the contents of the fruit are ejected through the orifice to several inches. (Typical of what takes place after being taken by a patient) In order that endosmose and exosmose may take place certain circumstances must be regarded, viz., first, the liquides on the opposite side of the septum must have an affinity for each other, secondly, the liquides must have an affinity for the membrane, and lastly, they must be miscible. There will be no diffusibility between oil and water for they are not miscible. There will also be but very little between fluids that act chemically on each other. The kind

of membrane also has an influence, though it is not necessary that an animal membrane should be used, yet the action will be more powerful and active through such than through an inorganic one. The action will take place through any porous solid, such for instance as burned slate, unglazed earthen ware, porous limestone &c &c, provided the above circumstances be regarded, but the action will be in a slower degree. We find in some authorities incorrect conditions under which endosmosis takes place. It is said to be the property by which rarer fluids pass through membranes into cavities containing denser fluids, this is wrong, for we

find that when alcohol and water are separated by a septum of animal membrane the endosmotic current is from the water towards the alcohol. this is not, because the alcohol is denser than the water, but because the water more easily wets the membrane, for if the water and alcohol be separated by a membrane composed of a thin lamina of caoutchouc then the endosmotic current is from the alcohol to the water, because the caoutchouc is more easily wetted by the alcohol than by the water. Some authorities state that the lighter liquid always moves towards the heavier. the error of this is readily shown by the fact that water endosmoses equally well to

alcohol which is lighter than it, and to salt water which is heavier, the fact is there is no general rule. It is found by experiment to make a vast difference when animal membranes are used which side is presented to the endosmotic current. The force with which a liquid will thus pass through the pores of a membrane is very great. Dutrochet ascertained in some of his experiments that a fluid might be raised, against a pressure of four and one half atmospheres or nearly seventy pounds to a square inch, but there can probably nothing definite be arrived at as regards the force, for when the action has gone on till a certain pressure is obtained, an hydraulic leakage takes

place backward through the pores and conceals the true action, there is but little doubt however that the action may be continued in many cases against a pressure of many atmospheres. As above stated, the activity of the action where animal membranes are used depends much whether the endosmotic current is from the external to the internal surface or vice versa. <sup>by</sup> Matteucci found that when the skin of the <sup>My</sup> Torpedo was employed with a solution of sugar on one side and water on the other, although there was always an endosmotic current from the water to the sugar, yet when the water was in contact with the internal surface of that membrane the activity of the current was four times

as great as when the external surface of the membrane presented to the water. Also when the mucous membrane of the stomach of a dog was employed as the septum and its internal surface in contact with the water the endosmotic current took place with such force and rapidity as to raise the liquid in the tube to 130 degrees whilst if the external surface of the membrane was in contact with the water the force was only able to raise the fluid in the tube 6 degrees in the same time, so we find, that endosmosis takes place much more readily from within out of the stomach than in the opposite direction, this is in fact in harmony with the physiological properties of that organ.

Matteucci also found that membranes are very rare where it makes no difference as to the endosmotic force which side of the membrane presents to the water, and it is a general rule that the endosmotic current takes place with greater facility from the internal to the external surface of organized or animal membranes, however the skin of the frog seems to form an exception, for when it is used as a septum between alcohol and water the endosmotic current is from the external to the internal surface, but at the same time while water endosmoses more readily from the external to the internal, a solution of mucous or albumen osmises more readily from the inter-

nal to the external surface, a fact which is of some interest when it is remembered that, it is in this direction that the secretion of mucous takes place, thus the water readily enters the pores of the skin and after mixing with the mucous it readily returns to the surface bringing the mucous with it, in this way the surface of the frog is constantly kept moistened by the mucous secretion.

Another partial exception is found in the fact that the most favorable direction to endosmosis between water and saccharine solution is not the same for the stomach of a ruminant and of a carnivorous animal, but yet there can be no general statement made on this subject. When animal mem-

branes become dry or altered by putrefaction we either do not observe the difference in the surfaces of the membrane or else no action at all takes place, thus giving an indication that it is owing to the physical conditions of the membrane which gives it many of its peculiarities. The exosmotic current bears no constant relation to that of the endosmotic, for in some circumstances the former is almost as great as the latter, and the fluids almost keep their original level. But after all that has been said, on this subject we find some authorities who maintain that absorption is a purely vital force, because it continues only during life, but this is not true, for imbibition

will take place in dead tissues, but more slowly than in the living, but this latter circumstance seems amply accounted for by the difference of condition between a mass of tissues whose fluids are all stagnant, and another in which an active circulation is taking place. It has also been maintained that the apparent selection of material which the absorbent vessels make is a vital act, but we find that the rejected part is either not soluble in the blood, in which case it could not endosmose, or that the membrane will not allow of the part to penetrate through its meshes on account of their peculiar structure, thus it is found that coloring matter which is not found in the lacteals

after its introduction into the stomach cannot in any way pass through the membrane separating the contents of the alimentary canal and the lacteals. It is wonderful and interesting to see how by divine Providence the laws governing all the phenomena, constantly taking place in the human system are exactly and perfectly adapted to our wants, and by their governing power keep the system in perfect harmony, penetrating every part to supply its wants and preventing no waste of substance but that, which would be detrimental to the health and comfort of our being.

The low diffusibility of albumen is a remarkable circumstance, without which our being could not be continued.

if it like many other substances was  
of high diffusibility then it would by  
capillary attraction pass off from  
our system leaving nothing behind  
to carry on the nutritive function with  
and emaciation and death would  
follow. The high diffusibility of  
urea. uric acid. chloride of sodium  
etc. forms another very interesting case  
of the divine laws governing our sys-  
tems. thus if urea. uric acid etc  
were of as low diffusibility as is that  
of albumen they would no more pass  
off than it. and they being the worn  
out particles of the system would  
be detrimental to health if retained  
for a single hour. therefore death must  
be the consequence of this also. and

many more facts of as much interest  
might be named, but for the want  
of room and time I must draw  
my subject to a close, first remark-  
ing that the study of physiology is  
of all others the one well adapted  
to fill the mind, with wonder,  
and lead us to reflect on the won-  
derful works of God.